U.S. Department of Transportation
Federal Aviation Administration

# Advisory Circular

**Subject:** Engine Critical Parts Requirements of 14 CFR 33.14.

**Date:** January 22, 2003
**Initiated By:** ANE-110

**AC No:** 33.14-0
**Change:**

## 1. PURPOSE.

This Advisory Circular (AC) provides definitions, guidance, and acceptable methods, but not the only methods, which may be used to demonstrate compliance with the engine critical parts integrity requirements of part 33, §33.14, of the Federal Aviation Regulations Title 14, Code of Federal Regulations. Section 33.14 contains requirements applicable to the design and life management of engine critical parts.

## 2. RELATED REGULATIONS

a. Section 33.4, Instructions for Continued Airworthiness.
b. Section 33.15, Materials
c. Section 33.19, Durability
d. Section 33.75, Safety Analysis

## 3. RELATED READING MATERIAL

a. AC 33.2B Aircraft Engine Type Certification Handbook, dated June 30, 1993
b. AC 33.3 Turbine and Compressor Rotor Type Certification. Substantiation Procedures dated September 9, 1968.
c. AC 33.4-1 Instructions for Continued Airworthiness dated September 11, 1980.
d. AC 33.4-2 Instructions for Continued Airworthiness: In-service Inspection of Safety Critical Turbine Engine Parts at Piece-Part Opportunity, dated March 8, 2001.
e. AC 33.14-1 Damage Tolerance for High Energy Turbine Engine Rotors, dated January 8, 2001.

**4. DEFINITIONS**.
For the purpose of this AC the following definitions apply.

(a) Approved Life: The mandatory replacement life of a part, which is approved by the Administrator and is listed in the Airworthiness Limitation Section (ALS) of the Instructions for Continued Airworthiness (ICA).

(b) Attributes: Are inherent characteristics of a finished part that determine its capability.

(c) Damage Tolerance: An element of the life management process that recognizes the potential existence of component imperfections. The potential existence of component imperfections is the result of inherent material structure, material processing, component design, manufacturing or usage. Damage tolerance addresses this situation through the incorporation of fracture resistant design, fracture mechanics, process control, or nondestructive inspection.

(d) Engine Critical Parts: Are those parts that rely upon meeting prescribed integrity requirements to avoid their primary failure, which is likely to result in a hazardous engine effect.

(e) Engine Flight Cycle: The flight profile or combination of profiles upon which the approved life is based.

(f) Engineering Plan: A compilation of the assumptions, technical data and actions required to establish and maintain the life capability of an engine critical part. The Engineering Plan is established and executed as part of the pre- and post-certification activities.

(g) Life Management: A series of engineering, manufacturing and service support activities that ensure critical engine parts are removed from service prior to the development of a hazardous condition.

(h) Low Cycle Fatigue (LCF). The process of progressive and permanent local structural deterioration occurring in a material subject to cyclic variations, in stress and strain, of sufficient magnitude and number of repetitions.

(i) Manufacturing Plan: A compilation of the part specific manufacturing process constraints, which must be included in the manufacturing definition (drawings, procedures, specifications, etc.) of the engine critical part to ensure that it meets the design intent as defined by the Engineering Plan.

(j) Primary failure: Failure of a part, which is not the result of the prior failure of another part or system.

(k) Safe Life: A LCF to crack initiation based process where components are designed, manufactured, substantiated and maintained to have a specified service life, which is stated in operating cycles, operating hours or both. Crack initiation is defined as a fatigue crack of 0.030 inches in length by 0.015 inches in depth.

(l) Service Management Plan: A compilation of the processes for in-service maintenance and repair to ensure that an engine critical part achieves the design intent as defined by the Engineering Plan.

## 5. BACKGROUND

The failure of an engine critical part is likely to result in a hazardous engine effect as defined in section 33.75. In order to avoid these types of failures it is necessary to meet specific integrity requirements by executing a series of life management activities. The life management requirements as defined in section 33.14 necessitate the development and execution of an Engineering Plan, a Manufacturing Plan and a Service Management Plan. These three plans define a closed-loop system which link the assumptions made in the Engineering Plan to how the part is manufactured and maintained in service.

The Engineering Plan defines the assumptions, technical data and actions required to establish and maintain the life capability of the part. The Engineering Plan and the approved life are established prior to introduction of the product into service and updated as new information becomes available.

In order to develop and execute an Engineering Plan, it is necessary to have a consistent and repeatable manufacturing method, which is captured in the Manufacturing Plan. The Manufacturing Plan is a compilation of the manufacturing process steps, controls and constraints such as drawings, procedures, specifications, machining instructions, etc. required to produce a part using a controlled process that meets the design intent as defined by the Engineering Plan.

The Service Management Plan provides the same control aspects as the Manufacturing Plan, but ensures the operational service assumptions and life contained within the Engineering Plan remains valid.

These plans may generate limitations, which are published in the Airworthiness Limitation Section of the Instruction for Continued Airworthiness.

This AC provides guidance for the establishment and execution of these plans.

## 6. GENERAL

**(a) Life System Approval**

In order to utilize a lifing system, the system must be approved by the Authority.

**(b) Identification of Engine Critical Parts**

Engine critical parts are those parts that rely upon meeting prescribed integrity requirements to avoid their primary failure, which is likely to result in a hazardous engine effect. Typically, engine critical parts may include disks, spacers, hubs, shafts, high-pressure cases and non-redundant mount components.

If a part is made of various sub-parts, which are finally integrated in an inseparable manner into a unique part, and any one of the sub-parts is identified as an engine critical part, the entire part is then treated as an engine critical part.

**(c) Attributes of a part**

'Attributes' include, but are not limited to, material mechanical properties, material microstructure, material anomalies, residual stress, surface condition, and geometric tolerances. Processes such as alloy melting practice, ingot conversion to billet or bar, forging, casting, machining, welding, coating, shot peening, finishing, assembly, inspection, storage, repair, maintenance, and handling may influence the attributes of the finished part. Environmental conditions experienced in service may also affect the attributes.

**(d) Content of a plan**

The Engineering Plan, Manufacturing Plan and Service Management Plan should provide clear and unambiguous information for the management of the engine critical parts. 'Plan' in the context of this AC, does not necessarily mean having all required technical information contained in a single document. If the relevant information exists elsewhere, the plan may make reference to drawings, material specifications, process specifications, etc as appropriate. It should be noted that these references should be clear enough to uniquely identify the referenced document and to allow the history of the individual part number to be traced.

## 7. GUIDANCE FOR DEFINING AN ENGINEERING PLAN.

**(a) Introduction**

The Engineering Plan consists of comprehensive life assessment processes and technologies that ensure that each engine critical part can be withdrawn from service before hazardous engine effects can occur. These processes and technologies address the design, test validation, and certification aspects as well as define those manufacturing and field management processes and attributes that must be controlled in order to achieve the engine critical part design intent.

**(b) Elements of the Engineering Plan**

The Engineering Plan should address the following subjects:

- Analytical and empirical engineering processes applied to determine the approved life.

- Structured component and engine testing conducted to confirm engine internal operating conditions and to enhance confidence in the approved life.

- Establishment of the attributes to be provided and maintained for the manufacture and service management of engine critical parts.

- Development and certification testing, and service experience required to validate the adequacy of the design and approved life. Any in-service inspections identified as critical elements to the overall part integrity, should be incorporated into the Service Management Plan.

**(c) Establishment of the Approved Life**

Determining the life capability of an engine critical part involves the consideration of many separate factors, each of which may have a significant influence on the final results.

Typically the approved life is a fraction of the calculated minimum fatigue life because of the following factors:

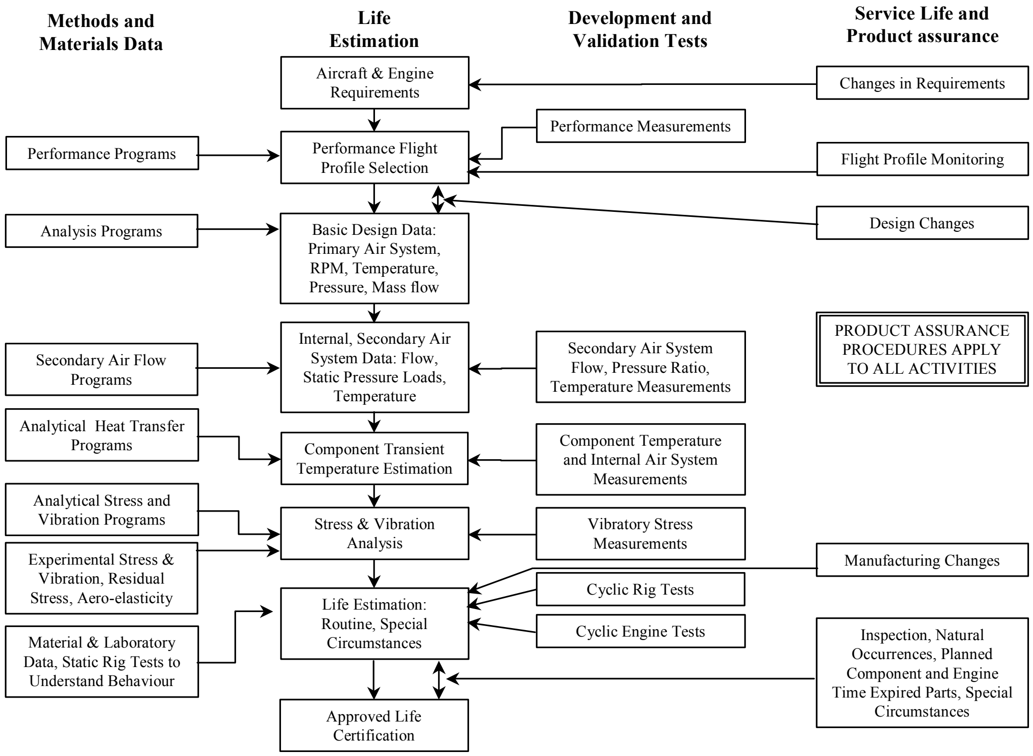
- Limitations of analytical capabilities in calculating cyclic life.

- Unknowns of field experience/service usage.

**(i) Rotating Parts**

The conventional gas turbine engine life management methodology (the "safe-life" method) consists of comprehensive processes and technologies related to the design, manufacture, test validation, certification and field management of high-energy rotors.

The following describes a typical process for establishing the approved life of rotating parts:




The major elements of the analysis are:

**Operating Conditions.**
For the purposes of certification, an appropriate flight profile or combination of profiles and the expected range of ambient conditions and operational variations will determine the predicted service environment. The engine flight cycle should include the various flight segments such as start, idle, takeoff, climb, cruise, approach, landing, reverse and shutdown. The hold times at the various flight segments should correspond to the limiting installation variables (aircraft weight, climb rates, etc.). A maximum severity cycle that is known to be conservative may be used as an alternative.

The corresponding rotor speeds, internal pressures, and temperatures during each flight segment should be adjusted to account for engine performance variation due to production tolerances and installation trim procedures, as well as engine deterioration that can be expected between heavy maintenance intervals. The range of ambient temperature and takeoff altitude conditions encountered during the engines' service life as well as the impact of cold and hot engine starts should also be considered.

The appropriateness of the engine flight cycle should be validated and maintained over the lifetime of the design. The extent of the validation is dependent upon the approach taken in the development of the engine flight cycle. For example, a conservative flight cycle where all the variables are placed at the most life damaging value would require minimum validation, whereas a flight cycle which more accurately represents some portion of the actual flight profile but is inherently less conservative, would require more extensive validation. Further refinements may be applied when significant field operation data are gathered.

**Thermal analysis.**
Analytical and empirical engineering processes are applied to determine the engine internal environment (temperatures, pressures, flows, etc.) from which the component steady state and transient temperatures are determined for the Engine Flight Cycle. The engine internal environment and the component temperatures should be correlated and verified experimentally during engine development testing.

**Stress analysis.**
The stress determination is used to identify the limiting locations such as bores, holes, changes in section, welds or attachment slots, and the limiting loading conditions. Analytical and empirical engineering processes are applied to determine the stress distribution for each part. The analyses evaluate the effects of engine speed, pressure, part temperature and thermal gradients at many discrete engine cycle conditions. From this, the part's cyclic stress history is constructed. All methods of stress analysis should be validated by experimental measurements.

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**Life analysis.**
A procedure should be developed which combines the stress, strain, temperature and material data to establish the life of the minimum property part. Plasticity and creep related effects should also be considered. Relevant service experience gained through a successful program of parts retirement or precautionary sampling inspections, or both, may be included to adjust the life prediction system.

The fatigue life prediction system is based upon test data obtained from cyclic testing of representative specimens and components and should account for the manufacturing processes that affect LCF, including fabrication from production grade material. Sufficient testing should be performed to evaluate the effects of elevated temperatures and hold times, as well as interaction with other material failure mechanisms such as high cycle fatigue (HCF) and creep. The fatigue life prediction system should also account for environmental effects, such as vibration and corrosion, and cumulative damage.

When the fatigue life is based on cyclic testing of specific parts, the test results should be corrected for inherent fatigue scatter. The factors used to account for scatter should be justified. In order to utilize this approach the test should be designed to be representative of the critical engine conditions in terms of the temperature and stress at the specific features, e.g. bore, rim or blade attachment details, of the part being tested. Appropriate analytical and empirical tools should be utilized such that the fatigue life can be adjusted for any differences between the engine conditions and cyclic test. In the event the test is terminated by burst or complete failure, crack initiation for this particular test may be defined using the appropriate crack growth calculations and/or fracture surface observations. It may also be possible to utilize the number of cycles at the last crack free inspection to define the crack initiation point. This approach requires an inspection technique with a high level of detection capability consistent with that used by the engine industry for rotating parts.

Test data should be reduced statistically in order to express the results in terms of minimum LCF capability (1/1000 or alternately -3 sigma). The fatigue life may be determined as a minimum life to initiation of a fatigue crack, defined typically as a crack length of 0.030 inch (0.75mm), but other methods may be used with the agreement of the Administrator.

**Damage Tolerance Assessment.**
Damage Tolerance assessments should be performed to minimize the potential for failure from material, manufacturing and service-induced anomalies within the approved life of the part. Service experience with gas turbine engines has demonstrated that material. manufacturing and service-induced anomalies do occur, which can potentially degrade the structural integrity of engine critical rotating parts. Historically, rotor life management methodology (safe-life method) has been founded on the assumption of the existence of nominal material variations and manufacturing conditions. Consequently, the methodology has not explicitly addressed the occurrence of such anomalies, although some level of tolerance to anomalies is implicitly built-in using design margins, factory and field inspections, etc. A damage tolerance assessment explicitly addresses the anomalous condition(s) and complements the fatigue life prediction system.

In the context of this rule, “appropriate Damage Tolerance assessments” recognizes that industry standards on suitable anomaly size and frequency distributions, and analysis techniques used in the damage tolerance assessment process are not available in every case. Where this is the case, compliance with the rule should be based on such considerations as design margins applied, application of damage tolerance design concepts, historical experience, crack growth rate comparisons to successful experience, etc.

An approach to the damage tolerance assessment process is contained within AC 33.14-1, which is applicable to material anomalies in Titanium alloy rotor components.

The damage tolerance assessment process typically includes the following primary elements:

- **Anomaly size and frequency distributions**.

A key input in the damage tolerance assessment is the size and rate of occurrence of the anomalies. This type of information may be statistical in nature and can be presented in a form that plots number of inclusions that exceed a particular size in a specified amount of material. Anomalies should be treated as sharp propagating cracks from the first stress cycle unless there is sufficient data to indicate otherwise.

- **Crack growth Analysis.**

This determines the number of cycles for a given anomaly to grow to a critical size. This prediction should be based upon knowledge of part stress, temperature, geometry, stress gradient, anomaly orientation, and material properties. The analysis approach should be validated against relevant test data.

- **Inspection techniques and intervals.**

Manufacturing and in-service inspections are an element of an overall strategy to address the fracture potential from inherent and induced anomalies. The interval for each in-service inspection should be identified. Engine removal rates and module and piece part availability data could serve as the basis for establishing the inspection interval. The manufacturing inspections assumed in the damage tolerance assessments should be incorporated into the Manufacturing Plan. Likewise, the assumed in-service inspection procedures and intervals should be integrated into the Service Management Plan and included, as appropriate, in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness.

- **Inspection Probability of Detection (POD).**

The (POD) of the individual inspection processes, such as eddy-current, penetrant fluid or ultrasonic, used to detect potential anomalies should be based upon the statistical review of sufficient quantities of relevant testing or experience. The relevance of these data should be based upon the similarity of parameters such as:

- Size, shape, orientation, location, and chemical or metallurgical character of the anomaly
- Surface condition and cleanliness of the parts

- Material being inspected (such as its composition, grain size, conductivity, surface texture, etc.).
- Variation of inspection materials or equipment (such as the specific penetrant fluid and developer, equipment capability or condition, etc)
- Specific inspection process parameters such as scan index
- Inspector (such as visual acuity, attention span, training, etc.)

**- Material anomalies.**

Material anomalies consist of abnormal discontinuities or non-homogeneities introduced during the production of the input material or melting of the material. Some examples of material anomalies that should be considered are hard alpha anomalies in titanium, oxide/carbide (slag) stringers in nickel alloys, and ceramic particulate anomalies in powder metallurgy materials unintentionally generated during powder manufacturing.

**- Manufacturing anomalies.**

Limited industry standards are currently being developed for manufacturing anomalies. Until these are officially released and with the approval of the Authority, company specific and/or industry data should be used in the damage tolerance assessments.

Manufacturing anomalies include anomalies produced in the conversion of the ingot to billet and billet to forging steps as well as anomalies generated by the metal removal and finishing processes used during manufacture and/or repair. Examples of conversion related anomalies are forging laps and strain induced porosity. Some examples of metal removal related anomalies are tears due to broaching, arc burns from various sources and disturbed microstructure due to localized overheating of the machined surface.

**- Service-induced anomalies.**

Service-induced anomalies such as non-repaired nicks, dings and scratches, corrosion, etc should be considered. Similarity of hardware design, installation, exposure and maintenance practice should be used to determine relevance of the experience.

**(ii) Static, pressure loaded parts**

**The general principles which are used to establish the Approved Life are similar to those used for rotating parts.**

However, for static pressure loaded parts, the approved life may be based on the crack initiation life plus a portion of the residual crack growth life. The portion of residual life used should consider margin to burst. If the approved life includes reliance on the detection of cracks prior to reaching the approved life, the reliability of the crack detection should be considered. Any dependence upon crack detection should result in mandatory inspections being included in the Service Management Plan and in the Airworthiness Limitations Section (ALS) of the Instructions for Continued Airworthiness (ICA). Crack growth analysis techniques should be validated experimentally.

Some construction techniques, such as welding or casting, contain inherent anomalies. Such anomalies should be considered as part of the methodology to establish the approved life. Fracture mechanics is a common method for such assessments.

In determining the life of the part, the temperature of the part, any temperature gradients, and any significant vibratory or other loads (for instance, flight maneuver) should be taken into account in addition to the pressure loads.

Manufacturing and in-service inspections are an element of an overall strategy to address the fracture potential. The intervals for each specified in-service inspection should be identified. Engine removal rates and module and piece part availability data could serve as the basis for establishing the inspection interval. The manufacturing inspections should be incorporated into the Manufacturing Plan. Likewise, the assumed in-service inspection procedures and intervals should be integrated into the Service Management Plan and included, as appropriate, in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness.

**Tests**

When using testing as part of the substantiation of the life of the part, the basic load cycle should be from substantially zero differential pressure to a value that simulates the most critical operation stress condition and returning to substantially zero differential pressure.

When a test is performed, the test pressure level should be adjusted to include the effects of stress due to thermal gradients in actual operation. When this is impossible, due to over-stress of regions other than the critical location or stress reversal in the Engine Flight Cycle for example, the fatigue capability in operation should be established by an additional analysis.

If the part is subject to loads in addition to those resulting from differential pressure (e.g. flight maneuver loads, engine mounting loads, etc.), an analysis should be made of these additional loads and their effect examined.

If the effect of these loads is small it may be possible to simulate them by an addition to the test pressure differential. However, if the loads are of significant magnitude or cannot adequately be represented by a pressure increment, the test should be carried out with such loads acting in addition to the pressure loads.

The part should be tested at the temperature associated with the most critical stress case or alternatively the test pressure differential may be increased to simulate the loss of relevant properties as a result of temperature.

Any fatigue scatter factors used should be justified.

During pressure testing the methods of mounting and restraint by the test facility or test equipment of any critical section should be such as to simulate the actual conditions occurring on the engine.

**Analytical Modeling Methods**
An analytical modeling method may be used to determine adequate fatigue life provided that the modelling method is validated by testing or successful field experience with parts of similar design.

**(iii) Other Parts**

For engine critical parts other than rotating parts or static pressure loaded components, a methodology for determining the approved life will need to be agreed with the Authority, using the general principles for rotating and static pressure loaded parts as a guideline.

**(d) Maintaining the Approved Life**

At certification, the approved life is based on predictions of engine operation, material behavior, environment etc. which all can be expected to influence the life at which the part must be withdrawn from service to avoid hazardous engine effects.

After certification it may be necessary to check the accuracy of such predictions, recognizing that many aspects, for example, the usage of the engine and its operating environment, may change during its operational life, especially with a change of ownership. It is important to use any service feed back to confirm that any assumptions made in the Engineering Plan remain valid, or are modified if required. The Engineering Plan should describe not only the basis of the approved life but also those actions subsequent to certification, which will be necessary to ensure that the approved life is appropriate throughout the operational life of the engine.

A regular review of the assumptions made when establishing the approved life may be required, depending on the conservative nature of the assumptions made when determining the approved life. The Engineering Plan should detail when such reviews should occur and what information will be required in order to complete the review.

Aspects which may be considered include, but need not be limited to:

- The frequency of approved life reviews
- Detailed inspection of service run parts, including time expired parts
- Review of flight plans
- Findings during maintenance
- Engine development experience
- Lessons learned from other engine projects
- Any service events

### (e) Influencing Parts

Engine critical parts are part of a complex system and other parts of the engine can have an impact on the engine critical parts and their life capability. Therefore, the Engineering Plan needs to consider these parts, and particularly changes to them. Examples include, a new, heavier turbine blade, a new mating part with a different coefficient of thermal expansion, and a change to a static part, well upstream of an engine critical part that modifies the thermal environment around the engine critical part.

## 8. GUIDANCE FOR DEFINING A MANUFACTURING PLAN

### (a) Introduction

The Manufacturing Plan is a portion of the overall integrity process intended to ensure the life capability of the part. The Engineering Plan includes assumptions about how engine critical parts are designed, manufactured, operated and maintained: each can have an impact on the part life capability. Therefore, it is essential to ensure that the attributes required by the Engineering Plan are maintained.

### (b) Elements of a Manufacturing Plan

The part specific Manufacturing Plan should consider the Attributes of the part delivered by the manufacturing process from raw material to finished part and should highlight all sensitive parameters identified as being significant with regard to part life which should not be changed without proper verification. Such parameters may include, but may not be limited to: material controls, including any zoned areas for special properties, manufacturing method specifications, manufacturing method order of application, inspection method and sensitivity, and any special part rough machining methods or finishing method(s), especially any methods intended to improve fatigue capability or minimize induced anomalies.

**(c) Development and Verification of the Manufacturing Plan**

The Manufacturing Plan should be reviewed and verified by the following key Engineering and Manufacturing skills:

- Engineering (Design & Lifing)
- Material Engineering
- Non-Destructive Inspection
- Quality Assurance
- Manufacturing Engineering (Development & Production)

Hence, this same skill mix should evaluate and approve process validation and the rules for change control and non-conformance disposition to ensure that the product of manufacturing is consistent with the design assumptions of the Engineering Plan. The intent is that:

- Manufacturing processes are developed and applied with the appropriate level of oversight to ensure the part life capability assumed in the Engineering Plan is consistently achieved. Substantiation programs are agreed up-front and executed as part of the process validation.
- Changes to such manufacturing processes and practices are visible and are not made without cross-functional review and approval.
- When a suspected non-conformance event occurs, it is reviewed with the appropriate skill mix prior to disposition.

The level of detail in the Plan may vary depending on the specific process step being considered, the sensitivity of the particular process step, and the level of control required to achieve the required life capability.

For instance, consider the case where a process specification exists to control the drilling of holes. If the use of this specification produces a hole that meets the life capability requirements for a flange bolthole, the plan may simply note that the flange bolthole will be produced per the specification. However, if a rim air hole requires cold expansion, after drilling per the specification, to meet the life capability requirements, it may be necessary to reference the cold expansion process in the plan.

## 9. GUIDANCE FOR DEFINING A SERVICE MANAGEMENT PLAN

### (a) Introduction

The Service Management Plan forms part of the overall process intended to maintain the integrity of engine critical parts throughout their service life. The Engineering Plan includes assumptions about the way in which the engine critical parts are manufactured, operated and maintained: each can have an impact on the life capability of the part. Therefore, it is essential to ensure that these assumptions remain valid. The Service Management Plan conveys the processes for in-service repair and maintenance to remain consistent with the assumptions made in the Engineering Plan.

### (b) Determining the acceptability of repair and maintenance processes

Repair and maintenance processes should be reviewed by the following key skills:

- Engineering (Design & Lifing)
- Material Engineering
- Non-Destructive Inspection
- Quality Assurance
- Product Support Engineering
- Repair Development Engineering

The role of this cross-functional review is consistent with that laid out for the Manufacturing Plan. The review should include process validation, change control and non-conformance to ensure the product of any repair or maintenance is consistent with the engineering requirement. The intent is that:

- Repair and maintenance processes and practices are developed with the appropriate level of oversight, and with due regard to their possible impact on the life capability of the part. Substantiation programs are agreed up-front and executed as part of the validation process.
- Changes to such processes and practices are visible to all parties, and are not made without cross-functional review and approval.

- When a suspected non-conformance event occurs, it is reviewed with the appropriate skill mix prior to disposition.

To achieve the necessary control of the application of those processes and practices, the procedures for repair and maintenance should be clearly articulated in the appropriate section(s) of the engine shop manual. These procedures should also include clearly delineated limits to these processes and practices that will ensure that engine critical parts maintain attributes consistent with those assumed in the Engineering Plan**.**

**(c) Service Management Aspects of Static Pressure Loaded Parts or Other Parts**

The difference in approach to lifing for static pressure loaded parts or other parts means that in addition to the approved life, Instructions for Continued Airworthiness may typically contain:

- A defined periodic inspection interval in the ALS.
- The inspection method(s) to be used.
- A detailed description of the area(s) to be inspected.
- Inspection result acceptability limits.
- Acceptable repair methods, if applicable.
- Any other instructions necessary to carry out the required inspection and allowable maintenance procedures.

## 10. AIRWORTHINESS LIMITATION SECTION

**(a) Repair and maintenance of engine critical parts**

To ensure a closed-loop between the in-service parts and the Engineering Plan, the importance of the limits to the repair and maintenance of engine critical parts should be highlighted in the engine shop manual. Further, since inappropriate repair or maintenance could impact the integrity of the part in a hazardous manner, visibility should be provided through the Airworthiness Limitations Section (ALS) of Instructions for Continued Airworthiness. Wording as, or similar to, that shown below should be placed in the appropriate section of the ALS.

> "The following airworthiness limitations have been substantiated based on engineering analysis that assumes this product will be operated and maintained using the procedures and inspections provided in the Instructions for Continued

Airworthiness supplied with this product by the Type Certificate holder, or its licensees. For engine critical parts and parts that influence engine critical parts, any repair, modification, or maintenance procedures not approved by the Type Certificate holder, or its licensees, or any substitution of such parts not supplied by the Type Certificate holder, or its licensees, may materially affect these limits. In such circumstances, appropriate airworthiness limitations should be obtained from the applicant responsible for the repair, modification, or substitute parts."

**(b) OEI considerations**

For rotorcraft engines desiring OEI ratings, the applicant should provide a method to account for the low cycle fatigue effects from the usage of the OEI ratings during the life of the engine. This may be accomplished by including in the ALS a method for adding a reasonable anticipated finite number of cycles to the expended life of the affected engine critical parts or by using appropriate life reduction factor(s) for each usage of the OEI power excursions.